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Corvette

1990

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Corn Refiners Association Inc.
1100 Connecticut Avenue, N.W.
Washington, D.C. 20036
202-331-1634

Member Companies and Plant Locations

ADM Corn Processing
(A division of Archer Daniels Midland Company)
P.O. Box 1470
Decatur, Illinois 62525
Plants:
Cedar Rapids, Iowa 52404
Clinton, Iowa 52732
Decatur, Illinois 62525
Montezuma, New York 13117

American Maize-Products Company
250 Harbor Plaza Drive
Box 10128
Stamford, Connecticut 06904
Plants:
Decatur, Alabama 35601
Dimmitt, Texas 79027
Hammond, Indiana 46320

Cargill, Incorporated
P.O. Box 9300
Minneapolis, Minnesota 55440
Plants:
Cedar Rapids, Iowa 52406
Dayton, Ohio 45413
Eddyville, Iowa 52553
Memphis, Tennessee 38113

CPC International Inc.
International Plaza
P.O. Box 8000
Englewood Cliffs, New Jersey 07632
Plants:
Argo, Illinois 60501
Stockton, California 95206
Winston-Salem, North Carolina 27107

Minnesota Corn Processors
400 West Main, Suite 201
Marshall, Minnesota 56258
Plant:
Marshall, Minnesota 56258

National Starch and Chemical Company
10 Finderne Avenue
Bridgewater, New Jersey 08807
Plants:
Indianapolis, Indiana 46221
North Kansas City, Missouri 64116

Penford Products Company
(a division of PENWEST)
P.O. Box 428
Cedar Rapids, Iowa 52406
Plant:
Cedar Rapids, Iowa 52406

A. E. Staley Manufacturing Company
(a subsidiary of Tate & Lyle, PLC)
P.O. Box 151
Decatur, Illinois 62525
Plants:
Decatur, Illinois 62525
Lafayette, Indiana 47905 (2)
Loudon, Tennessee 37774
Morrisville, Pennsylvania 19067

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CPC International Inc.

William H. Powell, Vice Chairman
National Starch and Chemical Company

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ADM Corn Processing

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ADM Corn Processing

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American Maize-Products Company

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Cargill, Incorporated

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Cargill, Incorporated

Samuel C. Scott
CPC International Inc.

Richard Jurgenson
Minnesota Corn Processors

Robert Nerhus
Minnesota Corn Processors

James A. Kennedy
National Starch and Chemical Company

H. Thomas Reed
Penford Products Company

Kenneth W. Kirby
Penford Products Company

L. H. Cunningham
A. E. Staley Manufacturing Company

J. P. Mohan
A. E. Staley Manufacturing Company

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Clinton Corn Processing Company

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CPC International Inc.

James W. Evans
American Maize-Products Company

R. S. Fisher
Hubinger

Harold Hellman
CPC International Inc.

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Robert M. Powers
A. E. Staley Manufacturing Company

Paul E. Ramstad
American Maize-Products Company

A. M. Robinson
Hubinger

Foreword

Annual reports tend to focus on current events. This ***Corn Annual***, like others, reports our industry's immediate developments: How much did we ship this year? How much did we export?

But, there's a bigger story in corn refining than any one year can demonstrate. For those of us who serve the industry, nothing is more impressive than refining's long-term transformation — in volumes shipped, in new products and in product applications.

This year's ***Corn Annual*** focuses especially on the increased importance of refined corn products in the American diet. Our feature story tracks this expansion through supermarket surveys which CRA has done for many years and pairs its analysis with a newly revised list of corn product uses.

The broader picture of corn refining's growth is set in context in the expanded statistical tables and graphs which complete the book. We hope that these will serve as a handy long-term reference for users of the ***Corn Annual***.

Finally, we would like to thank Mr. Paul E. Grunder, this year's CRA chairman, for his forward-looking exploration of the challenges which face the refining industry.

We hope that the 1990 ***Corn Annual*** continues in the tradition of previous annuals as a useful source of information about our industry and that you will contact us whenever we can answer your questions about corn and corn refining.

Robert C. Liebenow
President

Introduction

by Paul E. Grunder, Chairman Corn Refiners Association, Inc.

A new decade calls for a fresh approach to the problems and opportunities confronting our world and our industry. This year, as revolutionary changes coincide with the new decade, the need to reassess our world's challenges is even greater.

On the political and economic front, drastic reversals in the Communist world may produce a new free market economy for over 400 million people, if they can overcome an initial period of chaotic change. Following hard on the heels of that revolution, 1992 will bring massive evolutionary changes as western Europe reinvents the European Economic Community.

Elsewhere in the world, booming economies of the Pacific Rim nations, struggling new democracies in Latin America and desperately poor African nations all face difficult economic transitions.

Beyond politics and economics, the world of the 1990s presents other critical challenges. One of the most important, domestically and internationally, is the environment. Growing world population and worldwide demand for better living standards are requiring more and more resources at the same time environmental deterioration endangers the most basic necessities — fuel, clean air and water, even climate.

A related range of issues revolve around problems of safety and health. As scientific knowledge increases, we understand more clearly the linkages between the economic advances that pay for better, longer lives and the environmental concerns that produce safer food and healthier living conditions.

All these challenges present American agriculture and the corn refining industry with problems to solve and opportunities to grow.

Economic and political changes on the international scene will be especially important because of their effect on trade. The great danger is that individual nations will increasingly regress into protectionism, shrinking trade opportunities for the world generally.

The multilateral trade talks now taking place can solve only a part of this challenge: Developments like Europe 92, the reunification of Germany and the growth or stagnation of Eastern bloc economies will all play a role in determining the trade outlook.

If the 1990s do bring an era of new market openness, U.S. corn refiners will face an exceptional opportunity to expand both as suppliers of corn products and as suppliers of technology. As the refining industry grows, corn farmers will

Paul E. Grunder

Paul E. Grunder, a vice president of CPC International Inc. since 1977, became president of the Corn Refining Division in 1988. He is responsible for overseeing the company's worldwide corn refining operations.

A chemical engineering graduate of Grove City College, he joined CPC in 1971 as vice president, sales and marketing for U.S. corn wet milling operations and served as president of Penick Corporation, as president of the Corn Products Unit of CPC North America and as vice president for corporate development, CPC International Inc., before assuming his present position.

benefit from increased corn usage, and foreign consumers and economies will start to enjoy the advantages refined corn products already bring to the U.S.

Environmental challenges come in two forms: New restrictions on farming and processing practices which will force us to find ever more efficient ways to do more with less, and new opportunities for refiners to provide products that can help solve environmental problems.

Competitive pressures in the corn refining industry have for many decades spurred efficiency and technical innovation. Today's modern refiners continue the drive to increase energy efficiency and reduce wastes at the same time they are increasingly involved in solving other industries' environmental problems.

Refining's older environmental contributions are so accepted that we overlook them, like the role that corn starches play in reducing waste from paper making. Others are just now finding acceptance, like the use of alcohol first to replace lead in fuels and now to reduce carbon monoxide levels in the air.

Some, like degradable plastics, are newly introduced products whose advantages and uses are just being explored, while some are not yet commercial but hold hope for the future, like modified starch encapsulation which may allow more efficient delivery of active chemicals. Recent USDA research suggests that starch encapsulation of pesticides may reduce pesticide runoff into groundwater—a capsule example of a new environmental concern which refiners may help solve.

Beyond specific product applications, the technological experience in corn refining, the largest U.S. biotechnology industry, has been and will be increasingly important as biotechnology develops cleaner, more efficient solutions to our processing needs. As biotech applications grow, corn refiners will also face the challenge of providing larger supplies of corn syrups, one of the most versatile biotechnology feedstocks.

At the consumer level, increased concerns about health and safety echo the broader societal concerns about

SHIPMENTS OF PRODUCTS OF THE CORN REFINING INDUSTRY—1989

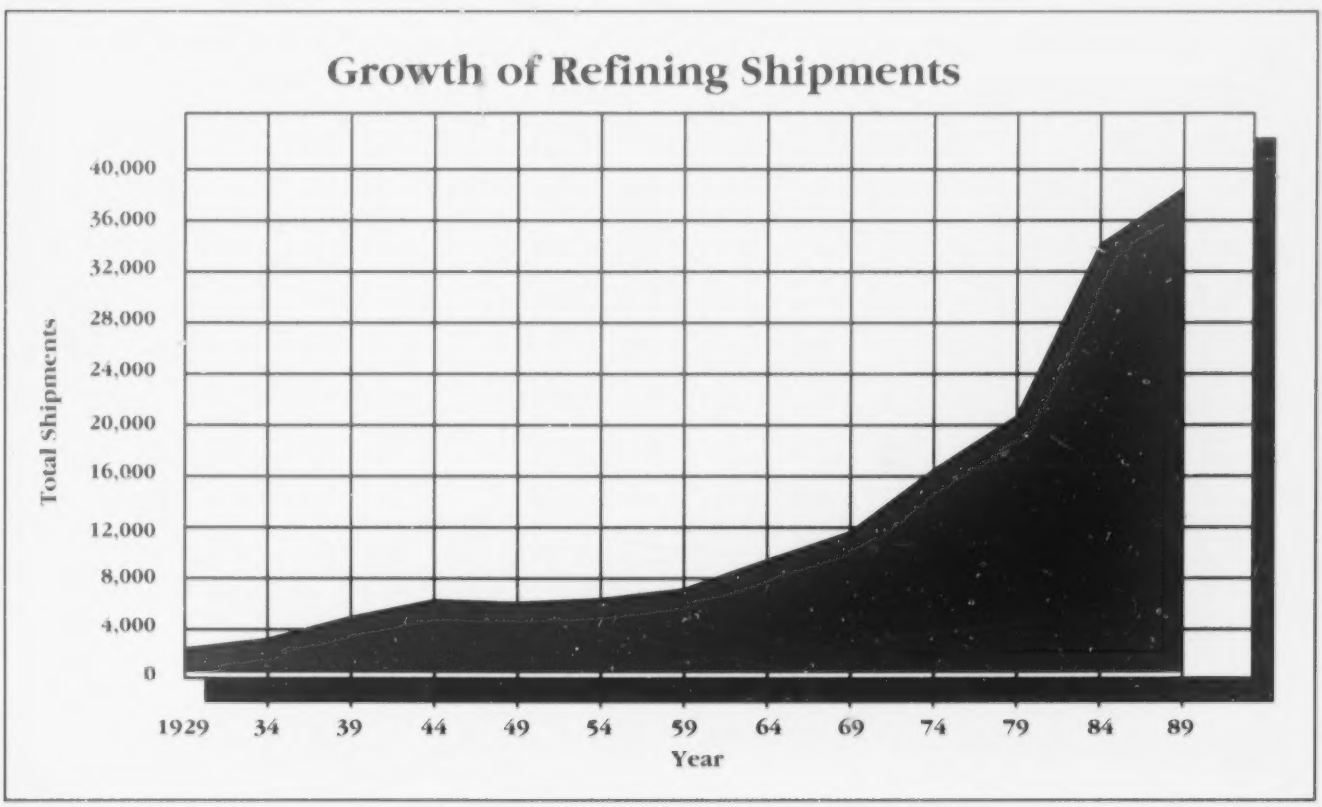
Starch Products	
(Includes corn starch, modified starch and dextrins)	4,487,737,000
Refinery Products	
(Includes glucose syrup, high fructose corn syrup, dextrose, corn syrup solids, maltodextrins)	21,581,648,000
High fructose corn syrup—42%	6,335,456,000
High fructose corn syrup—55%+	8,609,506,000
Total HFCS	14,944,962,000
Total—Domestic Basic Products	26,069,385,000
Total—Export Basic Products	313,842,000
Corn oil (crude and refined)	1,109,389,000
Corn gluten feed and corn oil meal	9,678,906,000
Corn gluten meal	1,814,543,000
Steepwater	169,337,000
TOTAL SHIPMENTS	39,181,402,000

Compiled for the Corn Refiners Association, Inc., by Ernst & Young. Statistics represent shipments by members of the association. Shipments are in pounds, commercial weights.

environment. Americans are paying more attention to issues of food quality and healthy food choices. For corn refining, part of the challenge is to solve problems inherent in food, like naturally occurring contaminants, to make food products even safer than they are now.

A further opportunity lies in the development and promotion of healthier food alternatives. Corn oil, recognized as a useful food choice in controlling cholesterol, is perhaps the best-known of our industry's contributions to date, but corn sweeteners and starches which make foods more palatable and convenient also help provide consumers with better food choices. Refiners have been quick to realize the opportunities in new food applications; our most recent supermarket survey demonstrates the ongoing expansion of food choices and corn product usage.

Corn refining achieved record growth during the 1980s, as refiners developed the potential for high fructose corn syrups and made major advances in starch, glucose, dextrose and ethanol. Now, the focus is shifting to new problems and opportunities. The challenges of the 1990s will, we expect, stimulate refiners to achieve a new range of creative uses for corn and a new round of growth.



Corn Products in the Supermarket

Corn refining is one of the success stories of 20th Century American industry. Decade after decade, refiners develop more products, use more grain, serve more industries, and ship more oil, starches, sweeteners and feeds. The statistics elsewhere in this book confirm the industry's growing role in the U.S. economy.

Another, more down-to-earth confirmation is evident in every American supermarket. A review of the labels on thousands of foods demonstrates, as nothing else can, how essential corn products are to consumers. Ultimately, corn refining succeeds because it serves the needs of the consumers who generate demand.

The Corn Refiners Association has periodically reviewed the use of corn products from the consumer perspective by studying the supermarket shelves. From 1958 to 1989, CRA sponsored eight studies, sending researchers into typical Washington-area supermarkets to read all the food labels and tally all listings of refined corn products.

The CRA studies show steady advances in the numbers and variety of grocery products containing refined products; collectively, they reflect the increasing importance of refining to U.S. food processors and consumers.

Only a fraction of the surge in corn use can be attributed to the increasing number of products available in supermarkets. From 1963 to 1988, the average number of items in a supermarket grew by about 300 percent.

The 1989 CRA survey, however, found 3,799 different uses of refined products, an increase of over 2,000 percent since 1962. Beyond the increase in raw numbers, the 1989 survey demonstrated the essential role of corn products in new food technologies like microwaved products, in healthier options like low-calorie and low-fat foods, and in more varied food choices.

Over all, the surveys reveal how closely refined corn products are linked to increases in the diversity and sophistication of products available to consumers. Looking at the CRA surveys is like reviewing a thirty-year collection of snapshots of the transformation in supermarkets.

In 1958, the earliest survey found corn products in relatively basic, traditional foods like bakery products, mayonnaise, candy, chewing gum, fruit juices, jams and jellies, prepared meats and baby foods.

It also reflected a smaller refining industry with a restricted range of products—

GROWTH OF REFINING SHIPMENTS

Year	Starch Products	Refinery Products	Oil	Feed Products	Total Shipments
		(In Millions of Pounds)			
1929	880	1,110	135	1,320	3,445
1934	765	1,700	140	1,240	3,845
1939	1,155	1,630	145	1,240	4,170
1944	1,515	2,630	205	1,765	6,120
1949	1,740	2,255	240	1,735	5,970
1954	2,150	2,435	255	1,980	6,825
1959	2,190	2,770	285	2,420	7,665
1964	2,495	3,850	365	3,120	9,830
1969	3,090	4,695	385	3,725	11,900
1974	3,910	7,085	435	4,845	16,275
1979	3,945	10,800	605	6,740	22,090
1984	4,185	17,920	985	10,940	34,030
1985	4,225	20,340	990	11,000	36,555
1986	4,390	20,535	1,070	10,630	36,625
1987	4,400	20,575	1,035	10,535	36,545
1988	4,600	21,475	1,130	11,350	38,725
1989	4,490	21,580	1,110	11,690	39,180

Estimated from industry, government sources. Chart does not include shipments of alcohol or byproducts from alcohol production. Product categories may not match totals because of rounding. Statistics represent shipments by association members.

starch, corn syrup, dextrose and oil. In fact, the CRA report on the study emphasized the role of corn starch and dextrins derived from starch in the packaging of grocery products as much as the food uses: "It is no exaggeration to say that almost every package you see in a supermarket, whether it contains food or not, has used a product of corn somewhere in its makeup."

To make the list of uses more extensive, it also counted products with sorbitol made from corn syrup.

The 1962 report was the first to supply numbers, citing 197 instances of corn product use. It found about 50 products each containing corn starch, corn syrup and dextrose and was the first study to mention maltodextrins in dried beverage mixes, corn gluten meal in pet food, and corn oil in margarine (Mazola margarine had been introduced as a new product in 1959).

Consumers were beginning the move toward convenience foods, which made their appearance in this study. Corn starch turned up in lasagna, chili con carne, pot pies, spaghetti sauce, beef stew and dried potato products.

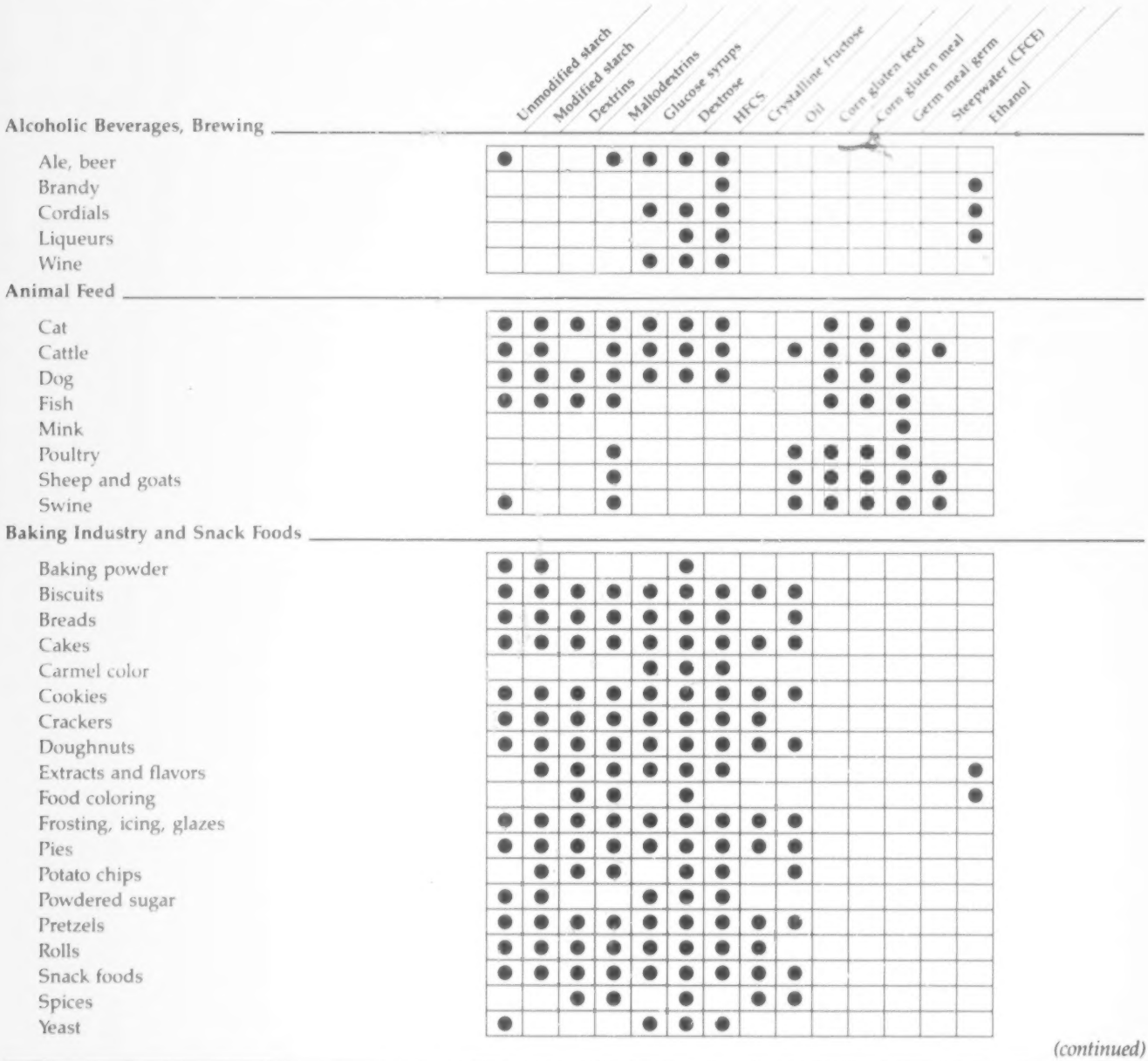
The 1968 survey marked a

MEMBER COMPANY PRODUCTS

	ADM Corn Processing	American Maize-Products Company	Cargill, Incorporated	CPC International Inc.	Minnesota Corn Processors	National Starch and Chemical Company	Penford Products Company	A.E. Staley Manufacturing Company
Starch Products								
Unmodified, food	●	●	●	●	●	●		●
Unmodified, industrial	●	●	●	●	●	●	●	●
Modified, food		●	●			●		●
Modified, industrial	●	●	●	●		●	●	●
Dextrins	●	●				●		●
Cyclodextrins		●						
Refinery Products								
Glucose syrups	●	●	●	●	●		●	●
Maltodextrins		●					●	●
Dextrose monohydrate	●			●				●
Dextrose anhydrous				●				
HFCS-42	●	●	●	●				●
HFCS-55	●	●	●	●				●
Crystalline fructose	●							●
Co-Products								
Crude oil	●		●					●
Refined oil	●			●				●
Corn gluten feed	●	●	●	●	●	●	●	●
Corn gluten meal	●	●	●	●	●	●	●	●
Corn germ or corn germ meal	●	●	●	●	●	●	●	●
Refined corn bran				●				●
Steepwater (CFCE)		●	●	●	●	●		●
Carbon dioxide	●							●
Other								
Ethanol, fuel/industrial	●			●	●			●
Ethanol, beverage	●							
Fermentation and other chemicals	●		●					●

Product lists are accurate as of publication date but may change with time.

REFINED CORN PRODUCTS: Applications



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major watershed, reflecting for the first time major developments like consumers' interest in health and diet foods, the burgeoning frozen food sector and the introduction of novelty and specialty foods from other cultures. It also mirrored the continued expansion of convenience food options.

Corn products showed up on the labels of 650 different items including new products like cheese spreads in pressurized cans, instant dry breakfast powders to be mixed with milk "for the man-on-the-go," preseasoned ready-made poultry stuffings, and packaged noodle and rice side dishes with sauces.

The survey cited early examples of health foods usage such as yogurt made with corn syrup, vegetarian hot dogs made with corn oil, powdered non-dairy coffee creamers, and

diet candies made with sorbitol.

"Looking over the popular frozen dinner section, we noted starch, syrups and caramel coloring on more than 20 labels," the report said, listing frozen food applications like corn syrup solids in fruits and corn syrup in frozen fish and hors d'oeuvres.

The hors d'oeuvres listing was just one example of a specialty food; the survey also found corn products in gourmet "flavor" sauces, chutneys, and fondue "for the fanciest occasion."

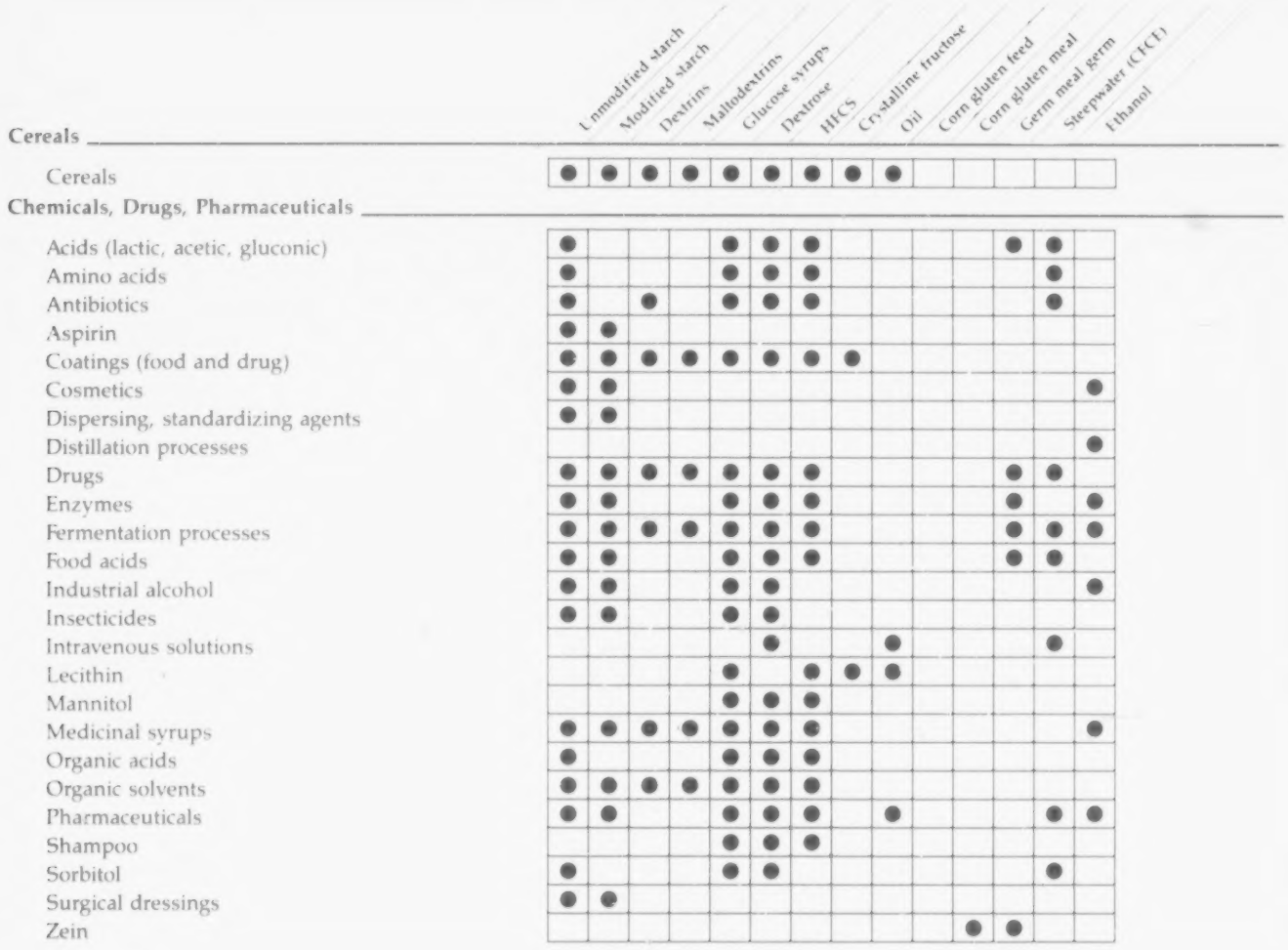
By 1971, refined corn applications were tallied in 800 products and by 1975 in 1,060 products. The 1975 report found starch in "new weight watchers dinners" and starch, oil and dextrose in "the new ready-made entrees for a quick and easy meal."

It also reflected the introduction of products like "hearty" style soups, health cereals, breakfast bars, frozen toaster breakfast foods and the new "helper" mixes for meats—all containing corn products.

The '75 survey also reviewed the role of corn refining in the typical market basket of foods which the Labor Department used to assess the cost of living and found that nearly half the processed foods in the market basket could contain refined corn products.

1982 produced major changes in the supermarket picture. Increasingly, CRA tabulators found multiple uses of refined corn ingredients in single finished products, a change that has prompted more recent surveys to emphasize "uses" more than items in their tallies.

	Unmodified starch	Modified starch	Dextrins	Maltodextrins	Glucose syrups	Dextrose	HFCS	Crystalline fructose	Oil	Corn gluten feed	Corn gluten meal	Germ meal germ	Steepwater (CFCE)	Ethanol
Beverages, Non-Alcoholic														
Carbonated		●		●	●	●	●	●						
Fruit drinks and juices		●	●	●	●	●	●	●						
Powdered mixes	●	●	●	●	●	●	●	●						
Building Materials														
Cardboard, or corrugated	●	●												
Ceramics	●	●	●											
Coatings (wood, metal)	●	●												
Cork products	●	●												
Fiberboard	●	●	●											
Fiberglass	●	●												
Glass or rock wool	●	●												
Laminated products	●	●	●	●	●									
Linoleum	●	●												
Paints and varnishes	●	●												
Plywood	●	●	●											
Tile, ceiling	●	●	●											
Wallboard	●	●	●		●	●								
Wall treatment compound		●												
Canners and Packers														
Berries	●	●		●	●	●	●	●						
Fruits	●	●		●	●	●	●							
Fruit fillings	●	●		●	●	●	●							
Fruits, candied					●	●	●	●						
Fruit pectin					●	●	●							
Soups	●	●	●	●	●	●	●	●						
Tomato sauces, including chili	●	●	●	●	●	●	●	●	●					
Vegetables	●	●			●		●							



Another, less significant change in methodology was to drop lecithin, sorbitol, lactic acid and caramel color from the count, since some of these can be made from other feedstocks.

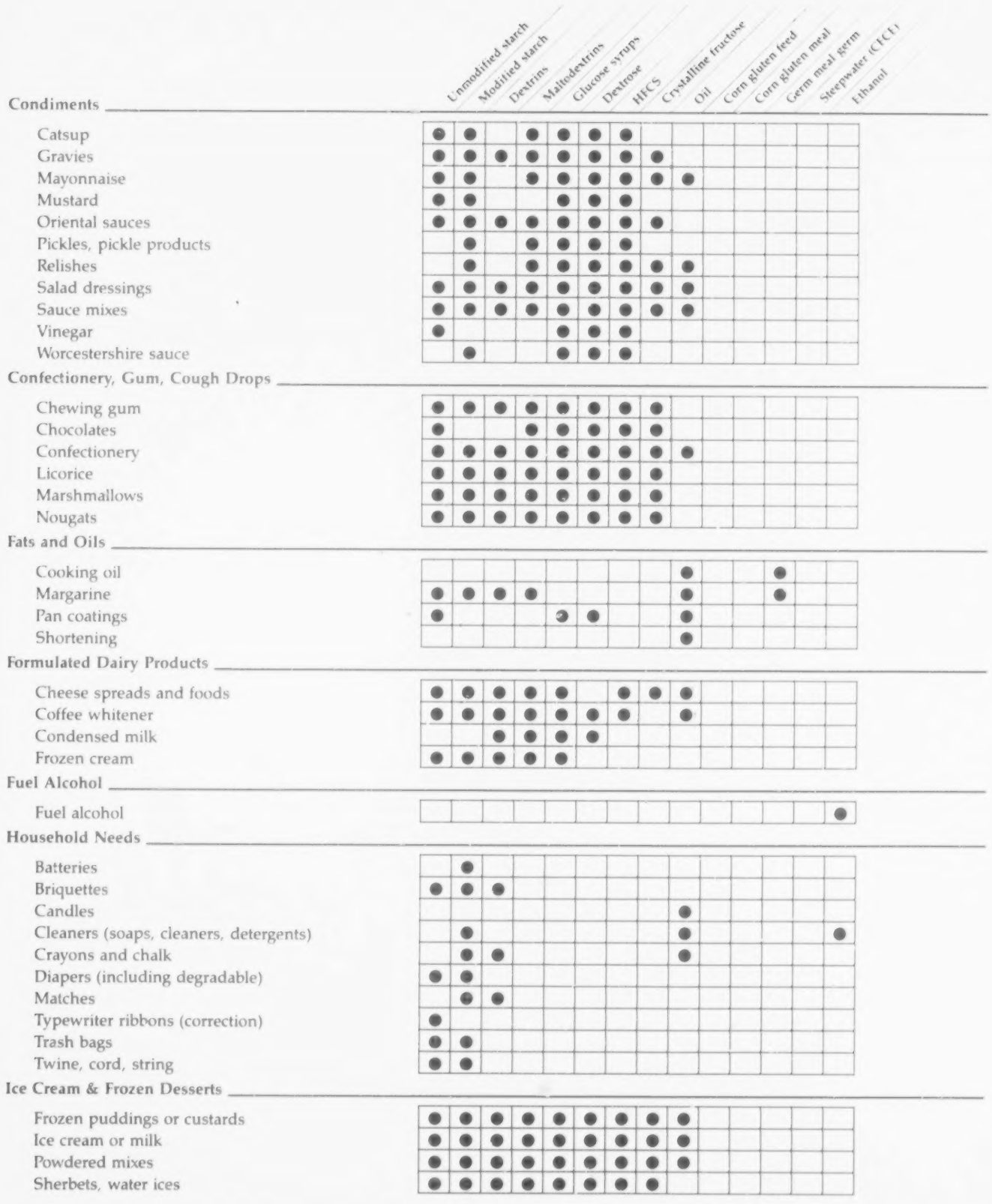
But the most significant landmark in the '82 survey was the dawning success of high fructose corn syrup, hailed as a "nutritive superstar." By the time of the survey, HFCS had been widely accepted in non-cola soft drinks and was gaining approval in colas.

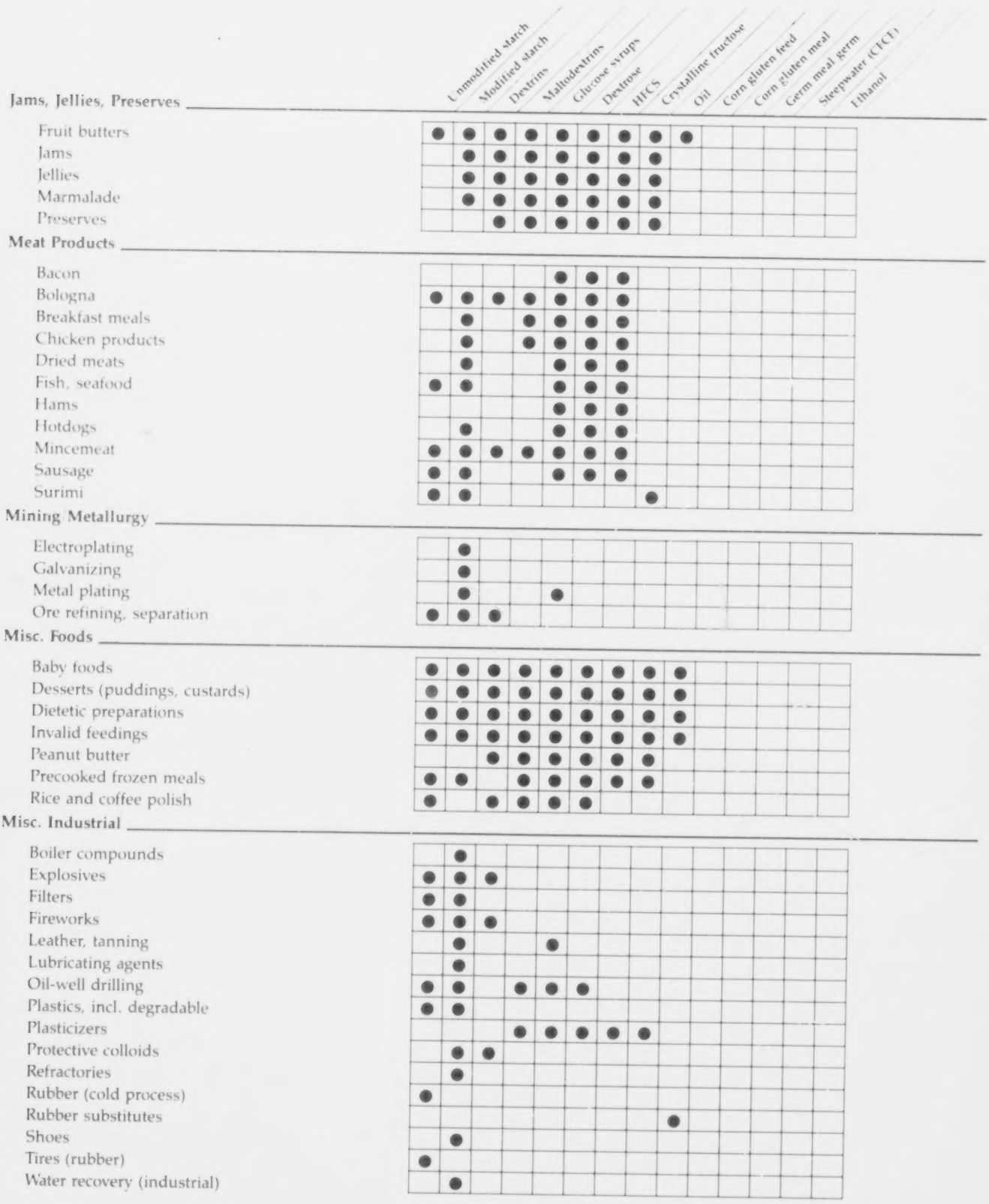
In addition, the survey found major growth in HFCS-sweetened ice creams, frozen desserts, and especially yogurts. Where the 1968 study found 20 products using corn ingredients in the freezer department, 1982 produced 38 examples in frozen yogurt and more than 50 examples in ice cream.

The number and variety of diet and health foods skyrocketed in the 1982 count, using more starches and syrups. In fact, the diet/health food sector provides many of the classic examples of food options which would not be possible without ingredients like corn starches and sweeteners. Modified corn starches, in particular, are essential to provide the consistency and appeal of many low calorie products.

The study also found that the use of corn in snack foods and chips, in pet foods, in processed meats like sausages and hot dogs, and in baked goods and sweetened breakfast cereals continued to grow.

Between 1982 and a follow-up survey in 1983, label listings of refined corn products jumped ten percent, to 3,038 uses.


Unmodified starch
Modified starch
Dextrins
Maltodextrins
Glucose syrups
Dextrose
HFCS
Crystalline fructose
Oil
Corn gluten feed
Corn gluten meal
Germ meal germ
Steepwater (CFCF)
Ethanol
Condiments
Catsup
Gravies
Mayonnaise
Mustard
Oriental sauces
Pickles, pickle products
Relishes
Salad dressings
Sauce mixes
Vinegar
Worcestershire sauce
Confectionery, Gum, Cough Drops
Chewing gum
Chocolates
Confectionery
Licorice
Marshmallows
Nougats
Fats and Oils
Cooking oil
Margarine
Pan coatings
Shortening
Formulated Dairy Products
Cheese spreads and foods
Coffee whitener
Condensed milk
Frozen cream
Fuel Alcohol
Fuel alcohol
Household Needs
Batteries
Briquettes
Candles
Cleaners (soaps, cleaners, detergents)
Crayons and chalk
Diapers (including degradable)
Matches
Typewriter ribbons (correction)
Trash bags
Twine, cord, string
Ice Cream & Frozen Desserts
Frozen puddings or custards
Ice cream or milk
Powdered mixes
Sherbets, water ices


Unmodified starch
Modified starch
Dextrins
Maltodextrins
Glucose syrups
Dextrose
HFCS
Crystalline fructose
Oil
Corn gluten feed
Corn gluten meal
Germ meal germ
Steepwater (CFCI)
Ethanol
Jams, Jellies, Preserves
Fruit butters
Jams
Jellies
Marmalade
Preserves
Meat Products
Bacon
Bologna
Breakfast meals
Chicken products
Dried meats
Fish, seafood
Hams
Hotdogs
Mincemeat
Sausage
Surimi
Mining/Metallurgy
Electroplating
Galvanizing
Metal plating
Ore refining, separation
Misc. Foods
Baby foods
Desserts (puddings, custards)
Dietetic preparations
Invalid feedings
Peanut butter
Precooked frozen meals
Rice and coffee polish
Misc. Industrial
Boiler compounds
Explosives
Filters
Fireworks
Leather, tanning
Lubricating agents
Oil-well drilling
Plastics, incl. degradable
Plasticizers
Protective colloids
Refractories
Rubber (cold process)
Rubber substitutes
Shoes
Tires (rubber)
Water recovery (industrial)

	Unmodified starch	Modified starch	Dextrins	Maltodextrins	Glucose syrups	Dextrose	HFCS	Crystalline fructose	Oil	Corn gluten feed	Corn gluten meal	Germ meal germ	Steepwater (CFCL)	Ethanol
Mixes, Prepared														
Cake mixes	●	●	●	●	●	●	●	●	●					
Cookie, brownie mixes	●	●	●	●	●	●	●	●	●					
Dessert mixes	●	●	●	●	●	●	●	●	●					
Dried foods	●	●	●	●	●	●	●	●	●					
Eggs, frozen or dried	●	●	●	●	●	●	●		●					
Frosting, icing mixes	●	●	●	●	●	●	●	●	●					
Gelatin mixes		●	●	●	●	●	●	●						
Gravy mixes	●	●	●	●	●	●	●	●	●					
Instant breakfast foods	●	●	●	●	●	●	●	●	●					
Instant tea		●	●	●	●	●	●	●	●					
Pancake, waffle mixes	●	●	●	●	●	●	●	●	●					
Quickbread mixes	●	●	●	●	●	●	●	●	●					
Seasoning mixes	●	●	●	●	●	●	●	●						
Soups, dried	●	●	●	●	●	●	●	●	●					
Paper, Paper Related Products														
Abrasive paper and cloth	●	●	●											
Bookbinding	●	●	●		●									
Color carrier (printing)	●	●	●											
Envelopes	●	●	●											
Glassine	●	●	●			●								
Labels	●	●	●											
Magazines	●	●	●											
Paper coatings	●	●	●											
Paper	●	●	●											
Parchment	●	●	●											
Printing inks	●	●	●											●
Straws	●	●	●											
Wallpaper	●	●	●											

Again, the growth was especially strong in categories like low calorie frozen dinners, yogurts, frozen desserts and ice cream products which reflected the adoption of HFCS.

Other areas of growth were frozen vegetables, including particularly vegetable combinations and vegetables in sauces, delicatessen meats such as lower fat chicken and turkey products, baked goods and snack chips.

By 1989, CRA researchers found 3,799 listings of refined corn products in an average-size supermarket. Again, the growth demonstrates the essential role of corn products in new and more varied food options.

Microwave cooking, which revolutionized food preparation and supermarket choices during the 1980s, is heavily dependent on corn products. By last year, microwaves were in use in 75 percent of American homes and in increasing numbers of offices and workplaces.

The CRA survey found instance after instance of microwave products relying on corn syrups, dextrose, maltodextrins and, especially, modified starches.

In categories like baking supplies the introduction of products like microwave mixes helped boost corn product listing by nearly 31 percent. The increased variety of rice side dishes doubled the use of refined products in that category.

Frozen dinners and entrees, most of them designed for microwave use, gave a major boost to refined product use;

tabulators found 170 instances of corn product ingredients in 116 frozen meat, poultry or seafood entrees. Starches, which can improve gravy texture and breadings and help limit the use of fats, produced 96 of the listings.

Corn products also contributed to the growing interest in healthier eating, as ingredients in new lines of turkey and chicken lunch meats and in the seasonings and sauces for ready-to-eat poultry products.

While oats gained the most attention in the breakfast cereal revolution, refined corn product use in the category also boomed, increasing by 165 percent. Corn usage was up, too, in special dietetic products like low-fat salad dressings, dietetic cake and frosting mixes and liquid diet products.

A new line of products gives a vivid example of the importance of corn refining: no-fat, no-cholesterol cakes and cookies recently introduced with national publicity use as many as five refined ingredients—dextrins, modified corn starch, maltodextrins corn syrup and dextrose—in a single product to achieve their results.

The '80s also saw increases in the popularity of ethnic and specialty foods, which included major increases in the wider variety of condiments and seasonings. From 1983 to 1988, the trade publication *New Product News* found that more new items were introduced in the condiment category than in any other food category.

Refined corn listings grew by 46 percent in pickles and pickle products; by 85 percent in salad dressings, jams and jellies; by 94 percent in spices and seasonings; and by 122 percent in sauces—all parts of the condiments category. In fact, corn product uses increased significantly in five of the top eight growth categories listed by *New Product News*.

1989 also confirmed the sweeping acceptance of high fructose corn syrup. While the

	Unmodified starch	Modified starch	Dextrins	Maltodextrins	Glucose syrups	Dextrose	HFCS	Crystalline fructose	Oil	Corn gluten feed	Corn gluten meal	Germ meal germ	Steepwater (CFCE)	Ethanol
Paste, Adhesives														
Adhesives	●	●	●		●									
Binders, binding agents	●	●	●		●									
Glues	●	●	●		●									
Gums	●	●	●		●									
Mucilages	●	●	●		●									
Pastes	●	●	●		●									
Syrups and Sweeteners														
Chocolate, cocoa	●	●	●	●	●	●	●	●	●					
Dessert toppings	●	●	●	●	●	●	●	●	●					
Fruit and table	●	●	●	●	●	●	●	●	●					
Low calorie sweeteners		●	●	●	●	●	●	●						
Soda fountain	●	●	●	●	●	●	●	●						
Textiles														
Color carrier (printing)	●	●	●											
Cord polishing	●	●												
Dyes and dyeing	●	●	●											
Oilcloth	●	●												
Sizing materials	●	●	●											
Textiles	●	●							●					
Windowshades, shade cloth	●	●	●											
Tobacco														
Tobacco		●	●	●	●	●	●							

'82 survey found significant HFCS use, by '89 it had effectively replaced sugar in non-diet soft drinks, including colas and become increasingly important in baked goods, dairy products, fruits, jams and jellies, prepared foods, and snacks.

While HFCS does not lead corn products in the number of label listings, today it is the dominant refined corn product in terms of volume. In the current year, refiners are expected to use 380 million bushels of corn to produce HFCS, almost all of which will be used in foods. In comparison, corn use for glucose, dextrose and starch together is estimated at 365 million bushels, much of which will go to industrial applications.

Another interesting footnote to the '89 survey is that people are not the only ones enjoying more food choices. The number of pet foods and pet snacks available has skyrocketed, and so has the use of corn products. Corn gluten feed or meal turned up on the labels of 67 pet products, along with 66 other listings of oil, starches or sweeteners.

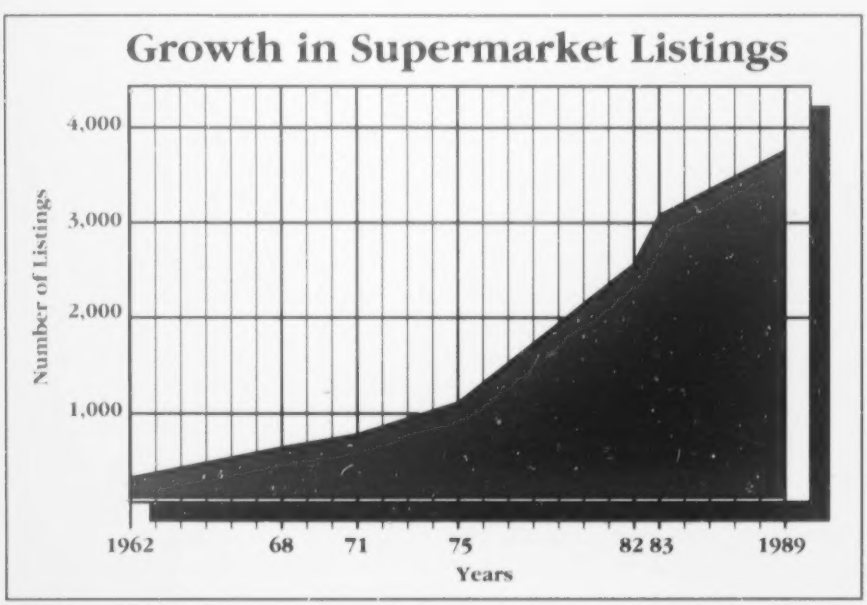
Compared to the 1962 survey, with its 197 listings of corn products, the '89 survey found 59 listings for dextrins, 67 for corn gluten, 146 for corn oil, 191 for corn syrup solids, 229 for maltodextrins, 384 for HFCS, 560 for dextrose (corn sugar), 938 for corn syrups and 1,225 for corn starches—a total of 3,799 uses.

Admittedly, CRA's surveys are not finely honed scientific studies that will support detailed comparisons. In part this reflects changes in food labeling regulations, changes in the level of detail in the tallies and changes in the supermarket itself.

And, none of the surveys from first to last can record all the refined corn uses in non-food products ranging from food packaging to paper goods, cleaning products, pharmaceuticals and cosmetics.

But it's still true that the surveys provide a series of vivid pictures of changes in the supermarket and in the role of corn refining.

To supplement the most recent survey and this article, CRA asked member companies to tally both the food and non-food applications for corn products. A comprehensive chart of the uses they reported accompanies this article, confirming again the essential role of the corn refining industry.

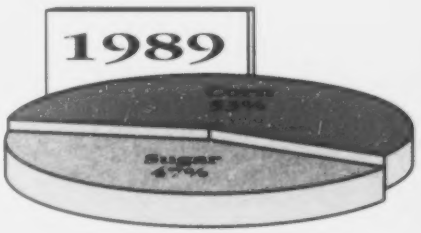


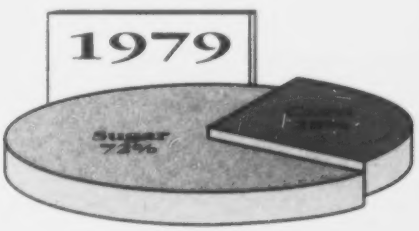
U.S. PER CAPITA SWEETENER CONSUMPTION

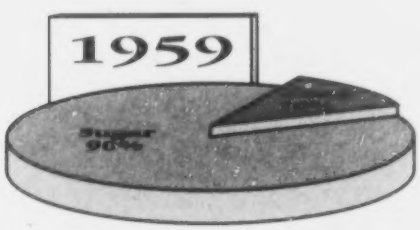
Crop Year	Refined Sugar	HFCS	Glucose	Dextrose	Total Corn Sweeteners	Honey and Edible Syrups	Total Caloric Sweetener
				Pounds, dry basis			
1959	96.4				11.5	1.9	109.8
1960	97.6				11.6	2.0	111.2
1961	97.8				12.0	1.9	111.7
1962	97.9				12.9	2.0	112.8
1963	97.3				14.2	1.8	113.3
1964	96.8				15.0	1.7	113.5
1965	97.0				15.1	1.8	113.9
1966	97.3				15.4	1.7	114.4
1967	98.5				16.2	1.4	116.1
1968	99.2				17.2	1.6	118.0
1969	101.0				18.2	1.6	120.8
1970	101.8	0.7	14.0	4.6	19.3	1.5	122.6
1971	102.1	0.9	14.9	5.0	20.8	1.4	124.3
1972	102.3	1.3	15.4	4.4	21.1	1.5	124.9
1973	100.8	2.1	16.5	4.8	23.4	1.4	125.6
1974	95.7	3.0	17.2	4.9	25.1	1.1	121.9
1975	89.2	4.9	17.5	5.0	27.4	1.4	118.0
1976	93.4	6.9	17.5	5.0	29.4	1.3	124.1
1977	94.2	9.1	17.6	4.1	30.8	1.4	126.4
1978	91.5	11.2	17.8	3.8	33.8	1.5	125.8
1979	89.3	14.4	17.9	3.6	35.9	1.4	126.6
1980	83.6	18.0	17.6	3.5	39.1	1.2	123.9
1981	79.4	22.2	17.8	3.5	43.5	1.2	124.9
1982	73.6	26.7	18.0	3.5	48.2	1.3	127.8
1983	71.0	31.1	18.0	3.5	52.6	1.3	130.4
1984	67.6	37.3	18.0	3.5	58.8	1.4	128.7
1985	63.4	44.1	18.0	3.5	65.6	1.4	132.8
1986	60.8	46.0	18.0	3.5	67.5	1.4	135.5
1987	62.4	47.5	18.0	3.5	69.0	1.4	132.8
1988	62.4	48.5	18.0	3.6	70.1	1.4	133.9
1989*	62.1	49.1	18.0	3.6	70.7	1.4	134.2

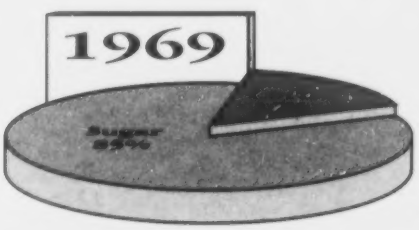
*Estimated

Source: USDA







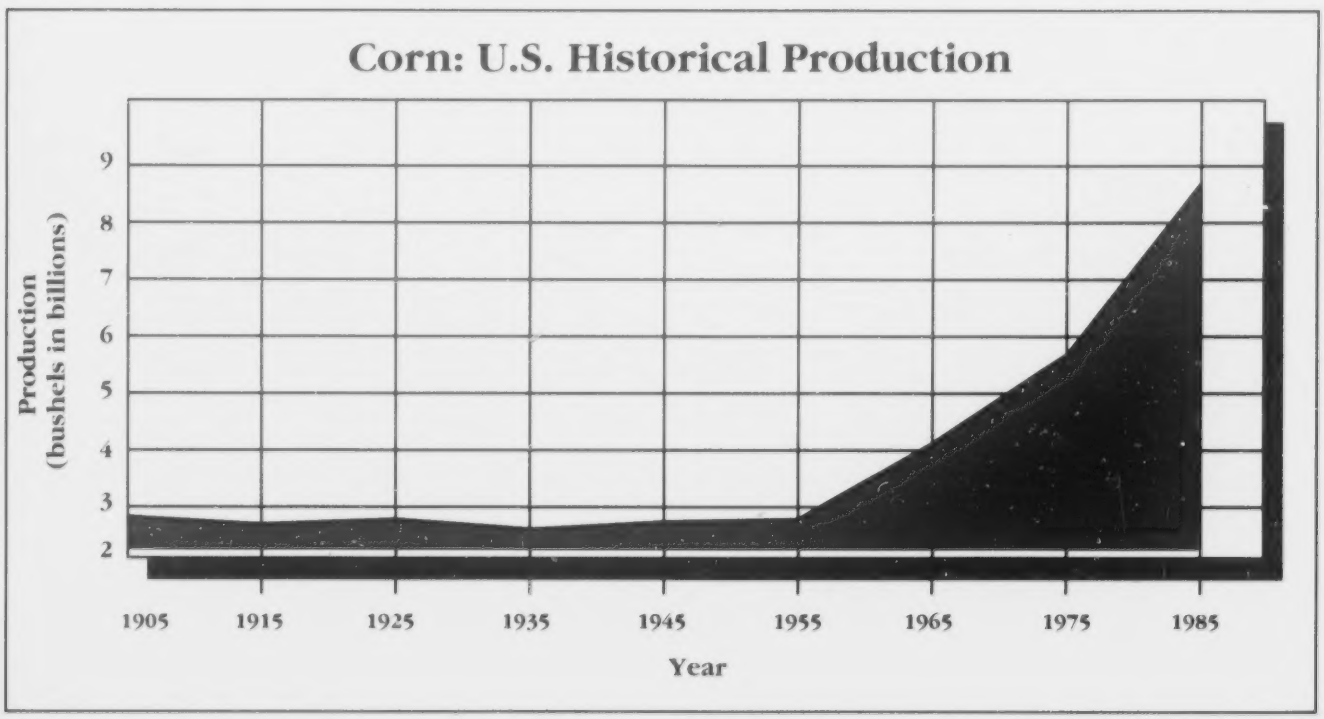


CORN: U.S. Historical Production

Year	Area Harvested	Yield	Production	Year	Area Harvested	Yield	Production
	in acres	*per acre*	*in bushels*		*in acres*	*per acre*	*in bushels*
1905	95,746,000	30.9	2,954,000,000	1966	57,002,000	73.1	4,167,608,000
1910	102,267,000	27.9	2,853,000,000	1967	60,694,000	80.1	4,860,372,000
1915	100,623,000	28.1	2,829,000,000	1968	55,980,000	79.5	4,449,542,000
1920	101,359,000	30.3	3,071,000,000	1969	54,574,000	85.9	4,687,057,000
1925	101,331,000	27.6	2,798,000,000	1970	57,358,000	72.4	4,152,243,000
1930	101,465,000	20.5	2,080,000,000	1971	64,123,000	88.1	5,646,260,000
1935	95,974,000	24.0	2,299,000,000	1972	57,513,000	97.0	5,579,832,000
1940	86,429,000	28.4	2,457,000,000	1973	62,143,000	91.3	5,670,712,000
1945	87,625,000	32.7	2,869,000,000	1974	65,405,000	71.9	4,701,402,000
1950	81,818,000	37.6	3,075,000,000	1975	67,625,000	86.4	5,840,757,000
1955	68,462,000	42.0	2,872,959,000	1976	71,506,000	88.0	6,289,169,000
1956	64,877,000	47.4	3,075,336,000	1977	71,614,000	90.8	6,505,041,000
1957	63,065,000	48.3	3,045,355,000	1978	71,930,000	101.0	7,267,927,000
1958	63,549,000	52.8	3,356,205,000	1979	72,400,000	109.5	7,928,139,000
1959	72,091,000	53.1	3,824,598,000	1980	72,961,000	91.0	6,639,396,000
1960	71,422,000	54.7	3,906,949,000	1981	74,524,000	108.9	8,118,650,000
1961	57,634,000	62.4	3,597,803,000	1982	72,719,000	113.2	8,235,101,000
1962	55,726,000	64.7	3,606,311,000	1983	51,483,000	81.1	4,174,678,000
1963	359,227,000	67.9	4,019,238,000	1984	71,915,000	106.7	7,674,020,000
1964	55,369,000	62.9	3,484,253,000	1985	75,224,000	118.0	8,876,706,000
1965	55,392,000	74.1	4,102,867,000	1986	69,159,000	119.3	8,249,864,000

Source: USDA

Statistics from 1955 to present represent corn harvested for grain, only. Before 1955, statistics include corn harvested for silage.



U.S. CORN FOR GRAIN: Yield and Production

STATE	AREA HARVESTED			YIELD			PRODUCTION		
	1987	1988	1989	1987	1988	1989	1987	1988	1989
	1,000 Acres			*Bushels*			*1,000 Bushels*		
ALA	250	170	180	72.0	44.0	81.0	18,000	7,480	14,580
ARIZ	15	13	13	140.0	155.0	145.0	2,100	2,015	1,885
ARK	65	60	58	115.0	100.0	122.0	7,475	6,000	7,076
CALIF	221	187	170	160.0	145.0	160.0	35,36[illegible]	27,115	27,200
COLO	690	800	930	155.0	160.0	145.0	106,950	128,000	134,850
DEL	148	140	133	75.0	70.0	100.0	11,100	9,800	13,300
FLA	105	65	80	69.0	58.0	74.0	7,245	3,770	5,920
GA	610	500	550	84.0	62.0	95.0	51,240	31,000	52,250
IDAHO	50	50	50	130.0	130.0	125.0	6,500	6,500	6,250
ILL	9,200	9,600	10,750	132.0	73.0	123.0	1,214,400	700,800	1,322,250
IND	4,880	5,000	5,200	135.0	83.0	133.0	658,800	415,000	691,600
IOWA	10,150	10,700	12,250	130.0	84.0	118.0	1,319,500	898,800	1,445,500
KANS	1,230	1,150	1,240	120.0	125.0	125.0	147,600	143,750	155,000
KY	1,140	1,100	1,180	104.0	73.0	116.0	118,560	80,300	136,880
LA	211	125	132	102.0	95.0	95.0	21,522	11,875	12,540
MD	460	420	400	78.0	65.0	110.0	35,880	27,300	44,000
MICH	1,980	1,600	1,970	97.0	70.0	113.0	192,060	112,000	222,610
MINN	4,800	4,700	5,600	127.0	74.0	125.0	609,600	347,800	700,000
MISS	150	150	140	80.0	60.0	70.0	12,000	9,000	9,800
MO	2,150	2,020	2,290	113.0	76.0	96.0	242,950	153,520	219,840
MONT	15	20	4	105.0	110.0	80.0	1,575	2,200	320
NEBR	6,200	6,600	7,100	131.0	124.0	120.0	812,200	818,400	852,000
NJ	85	79	71	104.0	70.0	102.0	8,840	5,530	7,242
N MEX	49	55	63	155.0	155.0	155.0	7,595	8,525	9,765
NY	600	540	570	109.0	85.0	93.0	65,400	45,900	53,010
NC	1,100	970	950	68.0	84.0	93.0	74,800	81,480	88,350
N DAK	500	380	465	93.0	58.0	75.0	46,500	22,040	34,875
OHIO	3,100	3,000	2,900	120.0	85.0	118.0	372,000	255,000	342,200
OKLA	66	72	78	107.0	95.0	118.0	7,062	6,840	9,204
OREG	24	19	22	165.0	158.0	160.0	3,960	3,002	3,520
PA	1,090	910	960	93.0	65.0	103.0	101,370	59,150	98,880
SC	375	335	340	78.0	58.0	91.0	29,250	19,430	30,940
S DAK	2,650	2,400	2,650	83.0	55.0	72.0	219,950	132,000	190,800
TENN	580	530	530	91.0	73.0	107.0	52,780	38,690	56,710
TEX	1,250	1,350	1,400	107.0	96.0	106.0	133,750	129,600	148,400
UTAH	20	22	20	140.0	124.0	132.0	2,800	2,728	2,640
VA	325	295	365	63.0	79.0	110.0	20,475	23,305	40,150
WASH	80	80	90	170.0	170.0	175.0	13,600	13,600	15,750
W VA	50	40	46	72.0	58.0	95.0	3,600	2,320	4,370
WIS	2,800	1,950	2,800	118.0	67.0	111.0	330,400	130,650	310,800
WYO	41	53	41	111.0	122.0	95.0	4,551	6,466	3,895
US	59,505	58,250	64,781	119.8	84.6	116.2	7,131,300	4,928,681	7,527,152

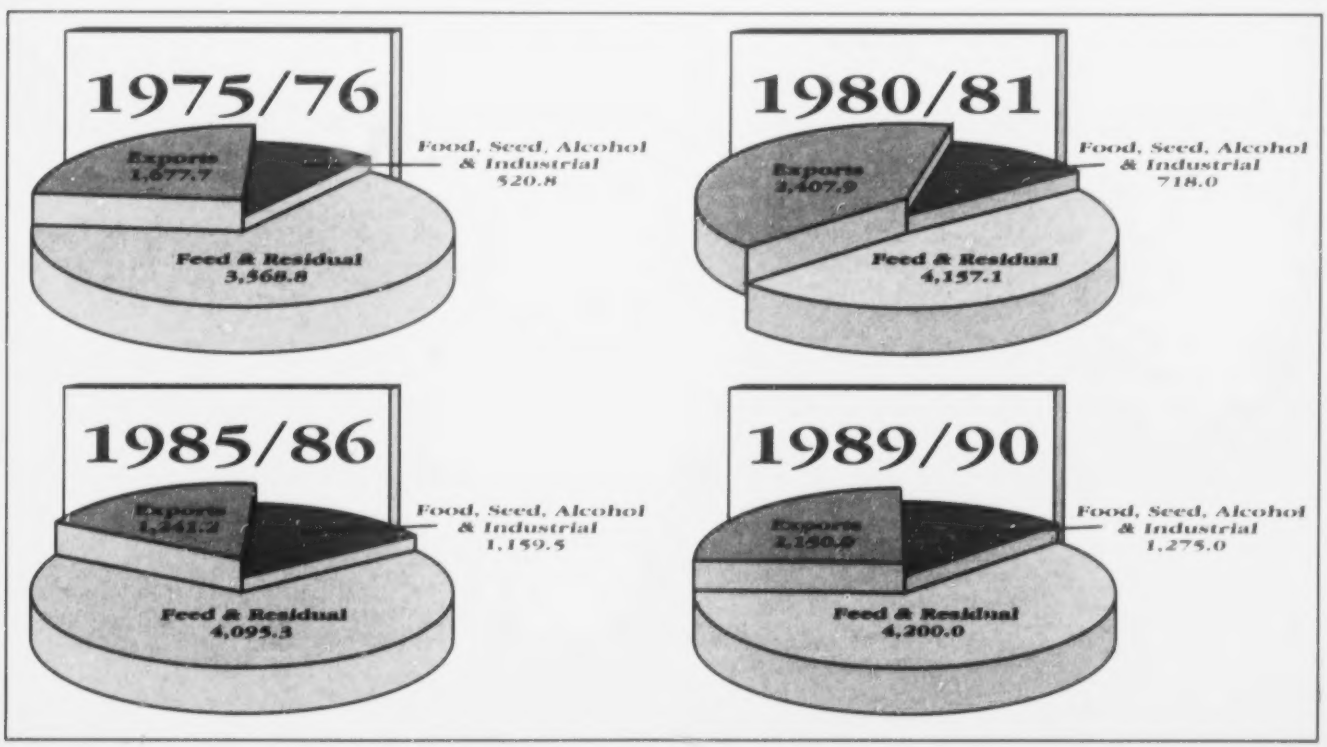
Source: USDA

CORN: Supply and Disappearance

Year beginning September 1	Supply				Disappearance						Ending stocks Aug. 30		
					Domestic use								
	Beginning stocks	Production	Imports	Total	Food, alcohol, and industrial	Seed	Feed and residual	Total	Exports	Total disappearance	Govt. owned	Privately owned [1]	Total
	Million bushels												
1975/76	558.0	5,840.8	1.7	6,400.5	500.7	20.1	3,568.8	4,089.6	1,677.7	5,767.3	0.2	633.0	633.2
1976/77	633.2	6,289.2	2.5	6,924.9	522.1	20.1	3,590.4	4,132.6	1,656.7	5,789.3	0.2	1,135.4	1,135.6
1977/78	1,135.6	6,505.0	2.6	7,643.2	561.5	19.5	3,717.2	4,298.2	1,909.1	6,207.3	3.5	1,432.4	1,435.9
1978/79	1,435.9	7,267.9	1.3	8,705.1	588.5	19.5	4,263.9	4,871.9	2,123.7	6,995.6	100.5	1,609.0	1,709.5
1979/80	1,709.5	7,928.1	0.9	9,638.5	619.5	20.0	4,549.3	5,188.8	2,415.4	7,604.2	260.1	1,774.2	2,034.3
1980/81	2,034.3	6,639.4	1.4	8,675.1	697.8	20.2	4,157.1	4,875.1	2,407.9	7,283.0	241.8	1,150.3	1,392.1
1981/82	1,392.1	8,118.7	1.1	9,511.9	777.8	19.4	4,168.6	4,965.8	2,009.5	6,975.3	280.1	2,256.5	2,536.6
1982/83	2,536.6	8,235.1	0.7	10,772.4	880.3	14.5	4,520.7	5,415.5	1,833.8	7,249.3	142.7	2,380.4	3,523.1
1983/84	3,523.1	4,174.7	2.7	7,700.5	956.0	19.1	3,817.6	4,792.7	1,901.5	6,694.2	201.5	804.8	1,006.3
1984/85	1,006.3	7,674.0	3.5	8,683.8	1,070.0	21.2	4,079.0	5,170.2	1,865.4	7,035.6	224.9	1,423.3	1,648.2
1985/86	1,648.2	8,876.7	10.6	10,535.5	1,140.0	19.5	4,095.3	5,254.8	1,241.2	6,496.0	545.7	3,493.8	4,039.5
1986/87	4,039.5	8,249.9	2.1	12,291.5	1,175.0	16.7	4,713.7	5,905.4	1,504.4	7,409.8	1,443.2	3,438.5	4,881.7
1987/88	4,881.7	7,072.1	4.0	11,957.8	1,212.0	17.2	4,735.0	5,964.2	1,734.5	7,698.7	835.0	3,424.1	4,259.1
1988/89 [2]	4,259.1	4,921.2	5.0	9,185.3	1,226.4	18.7	3,949.6	5,194.7	2,060.2	7,254.9	400.0	1,530.4	1,930.4
1989/90 [3]	1,930.4	7,589.7	3.0	9,523.1	---1,275.0---			4,200.0	5,475.0	2,150.0	7,625.0	750.0	1,148.1	1,898.1

[1] Includes quantity under loan and farmer-owned reserve. [2] Preliminary. [3] Projected.

Source: USDA

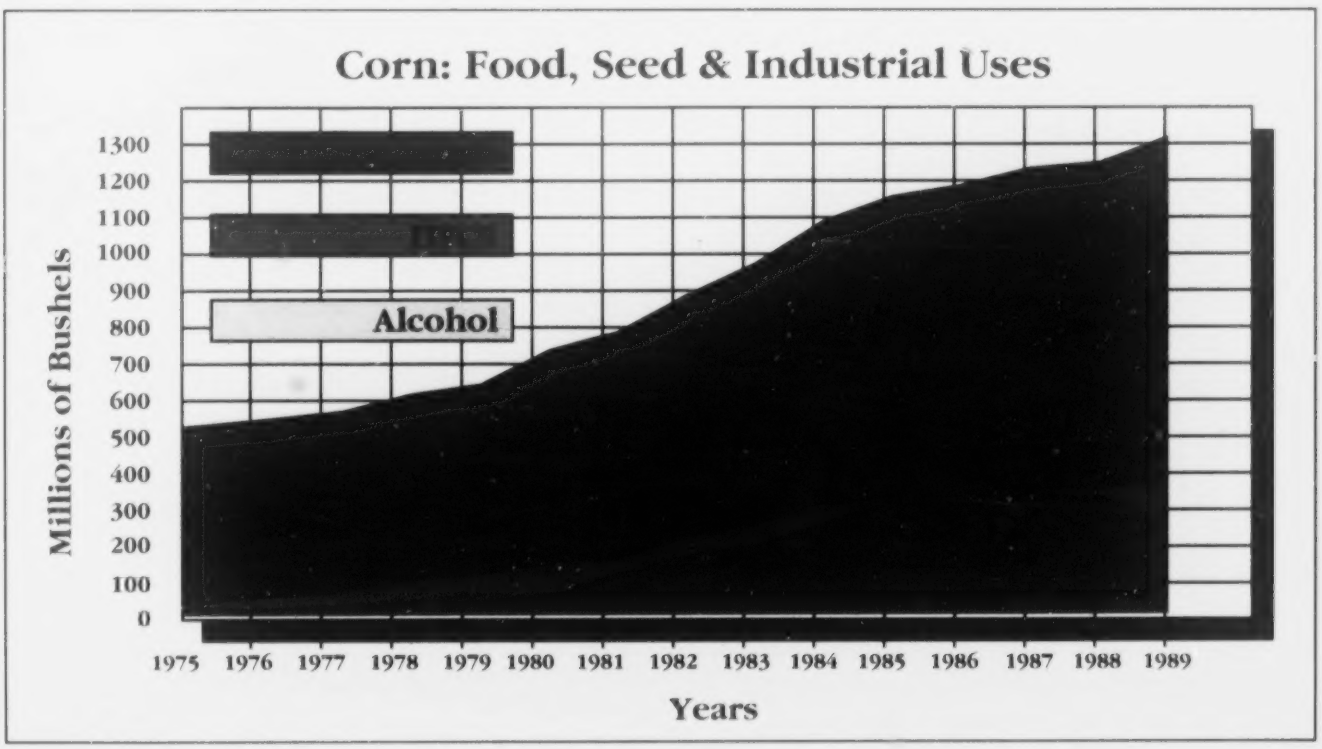


CORN: Food, Seed and Industrial Uses

Year	Wet-Milled Products				Dry-Milled Alcohol	Dry-Milled and Alkaline Cooked Products	Seed	Total
	HFCS	Glucose and Dextrose	Starch	Alcohol				
					Million bushels			
1975	45	162	116	5	20	154	20	522
1976	62	164	116	10	15	155	20	542
1977	80	170	124	10	20	158	20	582
1978	105	170	124	15	20	155	20	609
1979	127	170	120	25	20	158	20	640
1980	165	183	120	35	35	160	20	718
1981	185	183	130	83	35	162	19	797
1982	215	188	127	130	50	170	15	895
1983	256	189	147	150	50	164	19	975
1984	310	187	143	170	100	160	21	1,091
1985	328	188	152	185	127	161	19	1,160
1986	339	185	155	200	135	161	16	1,191
1987	359	187	167	200	136	163	17	1,229
1988	362	196	164	210	133	161	19	1,245
1989	380	200	165	245	135	161	19	1,305

Source: USDA-ERS

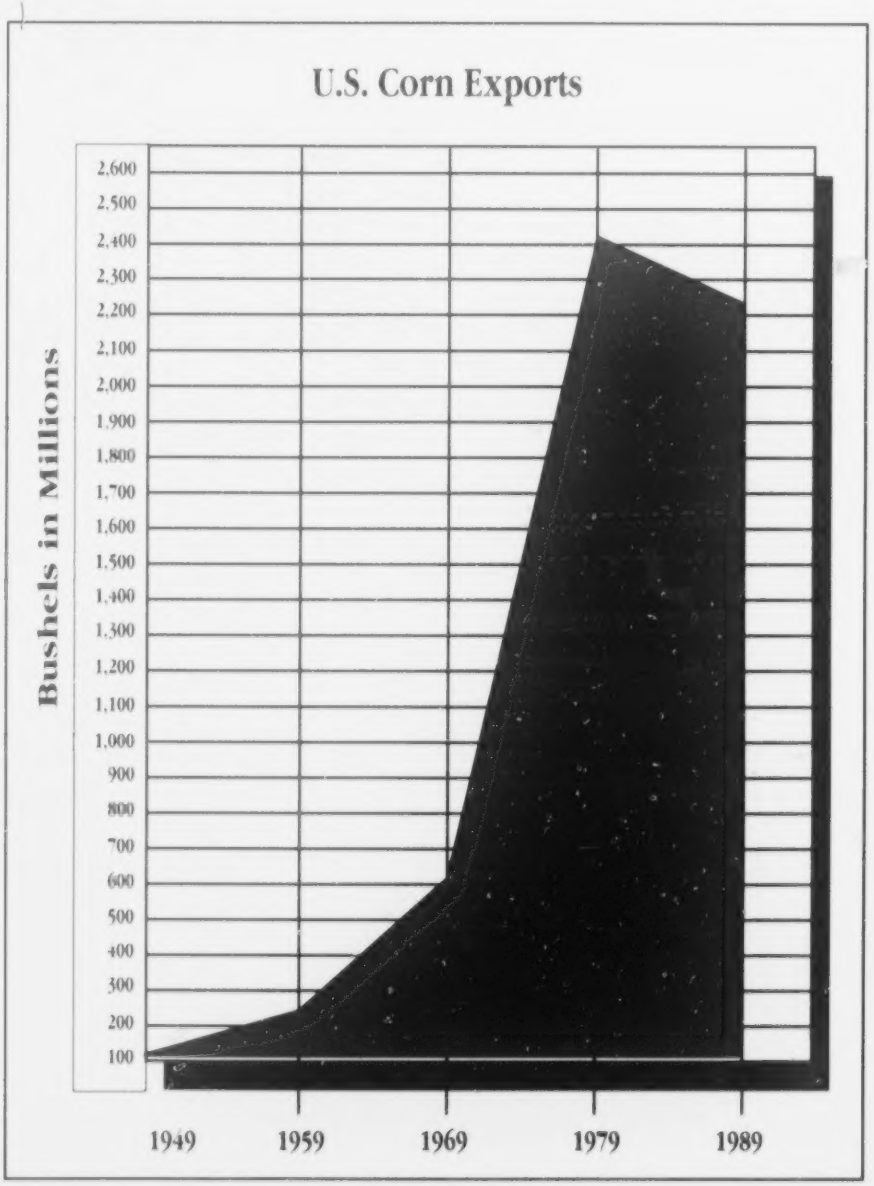
Year beginning Sept. 1



U.S. CORN EXPORTS

	in bushels
1949	106,000,000
1950	117,000,000
1951	81,000,000
1952	145,000,000
1953	104,000,000
1954	103,000,000
1955	120,000,000
1956	184,000,000
1957	200,000,000
1958	230,000,000
1959	230,000,000
1960	292,000,000
1961	435,000,000
1962	416,000,000
1963	500,000,000
1964	570,000,000
1965	687,000,000
1966	487,000,000
1967	633,000,000
1968	536,000,000
1969	612,000,000
1970	517,000,000
1971	796,000,000
1972	1,258,000,000
1973	1,243,000,000
1974	1,149,000,000
1975	1,678,000,000
1976	1,657,000,000
1977	1,909,000,000
1978	2,124,000,000
1979	2,415,000,000
1980	2,408,000,000
1981	2,010,000,000
1982	1,834,000,000
1983	1,902,000,000
1984	1,865,000,000
1985	1,241,000,000
1986	1,504,000,000
1987	1,608,000,000
1988	1,830,000,000
1989	2,225,000,000

Source: USDA



EXPORTS OF PRODUCTS FROM CORN

Product	1989	Units
Corn meal	111,030,923	Kilograms
Corn starch	61,561,473	Kilograms
Starch NESOI*	10,904,075	Kilograms
Corn oil, crude	98,211,210	Kilograms
Corn oil, once refined	27,230,969	Kilograms
Corn oil, fully refined	48,672,815	Kilograms
Glucose syrup blended with other sugars	895,220	Kilograms
Glucose syrup NESOI	20,228,512	Kilograms
Glucose syrup with 20-50% fructose	4,873,389	Kilograms
Chemically pure fructose	2,365,163	Kilograms
Fructose syrup with 50+ fructose	22,379,596	Kilograms
Fructose solids with 50+ fructose	3,747,415	Kilograms
Bran of corn	56,418	Metric tons
Corn gluten feed	4,825,066	Metric tons
Corn gluten meal	329,691	Metric tons
Other residues of starch manufacturing	12,045	Metric tons
Corn oilcake	74,291,383	Kilograms
Dextrins and other modified starches	24,321,201	Kilograms

* Not Elsewhere Specified or Included
Source: U.S. Department of Commerce

WORLD CORN SUPPLY AND DISAPPEARANCE

Exports	1988/1989	1989/1990
Argentina	2.5	2.5
South Africa	2.0	3.2
Thailand	1.4	0.9
China	3.7	2.5
United States	51.3	58.0
Others	3.4	3.9
TOTAL	64.3	70.9

Imports	1988/1989	1989/1990
Mexico	3.2	4.0
European Community-12	2.4	2.5
U.S.S.R.	17.9	18.5
Japan	15.9	16.1
Eastern Europe	2.4	3.5
China	0.0	0.5
Taiwan	4.2	4.3
Republic of Korea	5.7	6.7
Others	12.6	15.0
TOTAL	64.3	70.9

Production	1988/1989	1989/1990
Brazil	26.0	25.5
Mexico	10.1	10.0

Production Cont.	1988/1989	1989/1990
Argentina	4.8	6.0
South Africa	11.7	7.5
Thailand	4.2	3.8
European Community-12	28.6	25.8
U.S.S.R.	16.0	16.0
Eastern Europe	26.0	29.8
China	77.4	75.5
United States	125.2	191.2
Others	68.6	69.1
TOTAL	398.6	460.1

Utilization	1988/1989	1989/1990
European Community-12	29.3	29.0
U.S.S.R.	34.6	34.3
Japan	16.0	16.1
China	74.0	75.3
United States	132.7	144.9
Others	170.8	176.0
TOTAL	457.5	475.6

Ending Stocks	1988/1989	1989/1990
Foreign	38.4	34.4
United States	49.0	37.6
TOTAL	87.4	72.0

Source: USDA
Based on October/September year in millions of metric tons. 1989/90 represents a forecast total.

A Corn Timeline: 1900 to 1989

The following timeline, developed from a variety of sources, tracks the increased efficiency of corn production in the Twentieth Century and lists some of the major developments affecting the corn economy and, especially, the corn refining industry.

1900-1909 — Average yield: 25.9 bushels per acre. Man hours to produce 100 bushels: 147. Burpee begins marketing Golden Bantam sweet corn. Beall degerminator begins development of refined dry-milled products. Discovery of waxy corn in China. First successful double-cross corn hybrid developed.

USDA approves the term "corn syrup unmixed." Patents issued for continuous steeping, acid modified starches. Hydrol, pressed lump starch introduced.

1910-1919 — Average yield: 26.0 bushels per acre. Man hours to produce 100 bushels: 134. Hart-Parr Company, John Deere, J. I. Case, Henry Ford begin manufacturing gasoline-powered tractors. USDA develops first standard rules for uniform corn marketing. American Farm Bureau Federation established. First U.S. production of ammonium phosphate.

American Manufacturers Association of Products from Corn, now the Corn Refiners Association, Inc., established. First refined corn oil introduced.

1920-1929 — Average yield: 26.6 bushels per acre. Man hours to produce 100 bushels: 119. Development of cold-resistant hybrids begins. Hi-Bred Corn Company starts marketing hybrid seed. Two-row pickers sold in considerable numbers. Ammoniation of mixed fertilizers begins; synthetic sodium nitrate produced.

Corn refiners develop crystalline dextrose. Industry converts plants to closed process, improving quality control and controlling waste. Patents filed for corn gluten feed, corn gluten meal and corn oil meal.

1930-1939 — Average yield: 24.6 bushels per acre. Man hours to produce 100 bushels: 116. Improved tractors allow use of mechanical accessories. Golden Cross Bantam sweet corn hybrid introduced. Agricultural Adjustment Act of 1933 establishes first major price support and acreage reduction program. Commodity Credit Corporation established. Soil Conservation and Domestic Allotment Act passed. Solid urea and ammoniating solutions on market. Fertilizer granulation introduced.

Corn Industries Research Foundation established as part of the CRA. Refined corn protein from gluten marketed. Introduction of enzyme-converted corn syrups. Centrifuges introduced for starch separation.

1940-1949 — Average yield: 34.2 bushels per acre. Man hours to produce 100 bushels: 66. Commercial development of picker-shellers gathers momentum; 70,000 pickers in use by 1948. Commercial waxy maize production begins. Discovery of mutant for high amylose corn. By 1945, 90% of U.S. acreage planted in hybrids, especially double-cross hybrids. Product improvements make widespread use of ammonium nitrate possible. Beginning of rapid rise in concentrated superphosphate use. Introduction of 2,4-D herbicide.

Use of corn steepwater as growth medium for penicillin production during World War II. Cold water laundry starches, other new starches introduced. Refiners improve instrumentation techniques for process control.

1950-1959 — Average yield: 44.1 bushels per acre. Man hours to produce 100 bushels: 27. Self-propelled combines with corn heads developed; field shelling introduced. Self-contained batch dryers available. Soil bank program and P.L. 480 food aid program established. Flexible support prices established. National Corn Growers Association founded. Ureaform and ammonium polyphosphate introduced. Rapid rise in ammonium phosphate fertilizer use. Availability of herbicides reduces need for tillage.

Further introductions of cross-linked and modified starches. Ion-exchange technology improves corn syrup quality, allows production of wider variety of syrups. Introduction of maltodextrins.

1960-1969 — Average yield: 69.8 bushels per acre. Man hours to produce 100 bushels: 9. Farmers begin shift to single-cross and modified single-cross hybrids. ASCS established. Food and Agriculture Act of 1965, the first omnibus farm act, brings additional crops under voluntary programs. Commercial potassium nitrate produced in U.S. Development of atrazine and other pre-emergent herbicides.

First commercial shipments of 42 high fructose corn syrup. Technological advances increase efficiency, reduce water consumption.

1970-1979 — Average yield: 87.8 bushels per acre. Man hours to produce 100 bushels: 5. Corn exports boom, corn economy increasingly affected by world markets. Marketing gains in importance. Energy shortages encourage development of modern ethanol industry.

First continuous process HFCS plants. First commercial shipments of 55 high fructose corn syrup. Existing plants expanded and modernized, new refineries engineered to conserve energy. Industry begins move toward centralized computer process control.

1980-1989 — Average yield: 109.3 bushels per acre. Man hours to produce 100 bushels: 3. Increased adoption of computers for planning, research, cost control and accounting. Payment-in-kind program. Microwave popcorn introduced. Increased research into genetic modification of corn, genetic controls for corn pests. Low-till and no-till farming, corn irrigation increase.

Major soft drink companies approve use of 100% high fructose corn syrup; corn sweeteners become the dominant U.S. source for nutritive sweeteners. Starch-based degradable plastics developed. Refiners begin producing cyclodextrins, crystalline fructose.